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United States Army Commercial Off-The-Shelf (COTS) Experience The Promises and Realities

(March 2000)

James J. Barbarello
Director, Command & Control
Research, Development & Engineering Center
US Army Communications-Electronics Command
Fort Monmouth, NJ 07703, USA

Walter Kasian
Chief, Technology Planning Office
Command & Control Directorate
Research, Development & Engineering Center
US Army Communications-Electronics Command
Fort Monmouth, NJ 07703, USA

Summary: The US Army Communications-Electronics Command, commonly called CECOM, has been aggressively pursuing Commercial-Off-The-Shelf (COTS) materiel solutions for well over a decade. With that experience, CECOM has developed a strategy of "Adopt, Adapt, Develop". Through a series of case studies, this paper will explain when CECOM adopts COTS directly, adapts COTS products (by modifying as necessary to meet operational needs), and develops solutions when no COTS products will meet the Army's needs.

AMC: CECOM is one of four Major Subordinate Commands (MSCs) reporting to the Army Materiel Command. AMC as it is called, is responsible for all of the materiel used and maintained by the Army. One MSC addresses tanks and other ground vehicles. Another addresses missiles and other munitions, and Army aviation platforms. Yet another addresses all items used by the Army soldier. CECOM addresses all command & control, communications, computers, intelligence, electronic warfare, and sensor electronic systems and sub-systems used in the platforms acquired by the other AMC MSCs. Based on this mission we good-naturedly say, "We don't make the platforms used by the US Army...we make them better!"

The Electronics Revolution: CECOM has been involved in things electrical or electronic for over 80 years. The last 20 years, however, has been a time of extraordinary change. The immense progress in commercial technology, especially the tremendous growth in telecommunications, computing and consumer electronics (as reflected in Moore's Law's 18-month evolutionary cycle) has changed CECOM acquisition philosophy. The products we had to spend years developing only two decades ago can now be acquired from various commercial sources.

With strong emphasis on reducing system acquisition and sustainment costs, the US military has embraced (albeit to varying degrees) COTS solutions as a way to realize those cost savings while also speeding up equipment fielding. Over those last 20 years, the use of COTS products and components in military systems and platforms has gradually increased. In ground vehicles and missiles, this use has grown slowly. In CECOM's products, the use has been surprisingly expansive.

This move towards COTS is even incorporated into the US acquisition regulations. The 1994 Federal Acquisition Streamlining act, implemented by the Federal Acquisition Regulation (FAR) in October 1995, promoted a preference for using commercial items and directed US Government procurement teams to address the acquisition of commercial items as the norm for conducting business.

Two decades ago, the US Military was a significant customer in the electronics market. As such, it could mandate to many industries (like the US microelectronics manufacturers). Today, unique military business has dwindled to just a small fraction of the overall electronics markets. In other areas, however, our buying power has increased. As a corporate entity, the Army is a major user of

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computer systems and software. So where the Army can no longer expect microelectronics manufacturers to build devices especially for them, they can enter into arrangements with major commercial computer hardware and software suppliers (such as Microsoft Corporation) to obtain very competitive pricing arrangements.

Adopt, Adapt, Develop: CECOM strives to *adopt* commercial products and components wherever possible. This is especially desirable when the commercial product or component is offered in accordance with a commercial standard. In these instances, CECOM is not tethered to a specific manufacturer and the impact of technological obsolescence is greatly reduced.

Adoption of commercial products and components is not necessarily straightforward or risk free. For example, even when COTS is adopted, some evaluation or test is required to determine the COTS' suitability within the eventual military system. A laptop computer can be adopted for use in a command post where environmental conditions are controllable and within the scope of the product. That is not the case for extreme temperature, bounce and vibration environments. Today's commercial microcircuits are much more robust than those of 20 years ago. In most instances, even those products developed expressly for the military use such commercial devices. However, this does not apply to orbiting communications devices that would be subject to electromagnetic damage (of either natural or other nature). Failure to match the component or system to the using environment has proven costly for some commercial companies (as in the case of satellites damaged by electromagnetic effects), and could be fatal for the military.

When the COTS product cannot accommodate the using environment directly, CECOM has chosen to pursue the *adapt* route. For instance, a COTS product may have to be adapted to improve its robustness or reliability. Industry has periodically promoted products with immature technology. Easily breached security, delicate mechanical structure, or unproven software are but three of the immature characteristics encountered by CECOM in commercial products. In these instances, CECOM will work to adapt that technology to meet its customers' needs. (In the process, industry (and the commercial consumer) will benefit from applying the results of adaptation). One example is the Global Positioning System (GPS) receivers adapted by CECOM in the late 1980's from the products initially developed by Rockwell-Collins and Magellin. The resultant PLGR (Portable Lightweight GPS Receiver) made its mark in the deserts of Iraq in 1991.

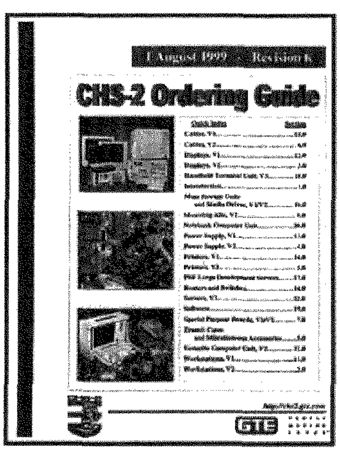
Adaptation is also required when the target product must interoperate with other portions of the military host system, whether they are other commercial products or components, or items resulting from military development. As an example, Asynchronous Transfer Modem (ATM) switching became very popular a few years ago. CECOM desired to incorporate this technology into its Mobile Subscriber Equipment (MSE) communications system. The commercial ATM products, however, had to be adapted to work within the MSE system (which is a combination of commercial and military developed sub-systems).

While the *Adopt* and *Adapt* approaches work for the majority of applications, there are instances where commercial industry will not (or cannot) provide appropriate solutions. One classical example was one of our sister MSC's need for a replacement for the venerable Jeep. The Tank and Automotive Command (TACOM) attempted to adapt commercial vehicle technology with a product called the CUCV. This slightly beefed-up commercial vehicle failed miserably in field environments. TACOM then pursued development of a new vehicle that it labeled the HMMWV (the venerable "Hummer"). As in many instances, the military development satisfied the Army's need while also providing industry with a new product for their commercial market.

In fact, except in a minority of instances, military Research & Development investment does not fully fund military development. Rather, it acts as an incentive, a "seed", to entice industry to enter into a dual-use program. In such programs, the initial development funded by the military results in a future capability or product that can be commercialized. The military then uses the industry's production capacity to fulfill its needs at reduced cost, resulting in a win-win solution for both parties. A classical example is image intensifying night vision devices initially developed by CECOM and then adapted for other markets by industry around the world.

CECOM has adopted, adapted, and developed several products since it began its relentless pursuit of COTS solutions. The following four case studies explain how CECOM has used the Adopt, Adapt, Develop approach in specific instances.

Case Study #1, CHS: Since the advent of ENIAC in the 1940's, the military has striven to incorporate computing. The development of the COBOL high level programming language was also driven by the military; the model they used up until the 1980's. When the Military Computer Family of unique computers and the ADA programming language were eclipsed by the ever-expanding commercial computer industry, CECOM realized it was time for a change. In the early 1990's the Project Manager (PM) for Common Hardware and Software (CHS) found a new way to do business. Against the conventional wisdom (and significant inertia) of military developers and acquirers, PM CHS established a (then) revolutionary acquisition instrument. Called CHS-1, it was essentially an "ordering catalog" for commercial computer hardware and software. It contained products from mainstream computer suppliers and niche companies alike. With the availability of this convenient method for obtaining the latest available technology, Army PMs began to incorporate CHS products into their systems. A prime example is ABCS, the Army Battle Command Systems. In the latter half of the 1990's CECOM and its Program Executive Officer (PEO) team members proposed a new concept to the Army; digitize the battlefield. At the heart of this concept was ABCS, a system of tactical battlefield systems for maneuver control, artillery, intelligence, logistics, air defense, and fire control. CHS hardware and software (and other COTS products) were injected into the systems resulting in the highly successful Task Force XXI experiment that caused the Army to adopt the digitization strategy.



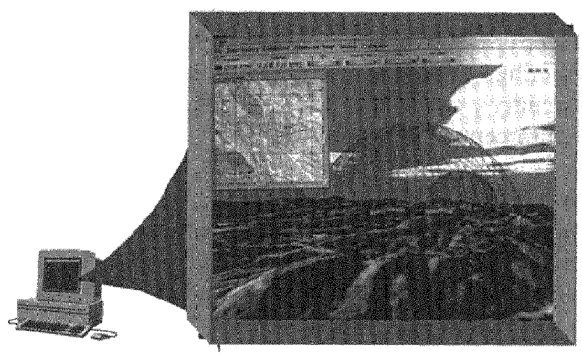
In 1999, PM CHS issued its second ordering catalog, CHS-2, administered by GTE Systems for the Project Manager. As indicated in the CHS-2 Ordering Guide, CHS-2 provides the tactical Army and the Defense Department with computer products ranging from hand held to RISC-based server class machines. CHS-2 products include life-of-contract warranty and 72-hour return/replacement, 24-hour hotline, and regional support centers located world-wide. Along with the computers, the hardware product mix includes printers, displays, storage devices and other peripherals. Hardware is supplied as Version 1, defined as commercial, Version 2, defined as rugged, and Version 3, designed for a greater degree of handling and more severe environments. Wide arrays of software products (such as operating systems, integrated business packages, programming languages and development tools) are also available. Commercial suppliers of the products include Sun Microsystems and Microsoft Corporation. As technology advances, the offered products are updated with newer ones.

While CHS contains a mix of adopted (pure COTS) and adapted (ruggedized COTS) products, at the component level (e.g., circuit boards, memory, drives, bus, etc.), everything is adopted COTS. At the sub-system level, adaptation mechanisms include specially designed exterior cases, specially designed removable hard disk drive encasements, ElectroMagnetic Interference (EMI) gasket lens filtering, special mounting (restraints for high-risk circuitry), stiffening of printed circuit boards, and reinforcement of components.

While CHS is more or less taken for granted as the *only* way to do business in the computer arena, this was not always the case. Initially, there was significant resistance from acquirers and users alike. The acquirers warned that commercial products could not meet military operational needs and would not be sustainable. They predicted that non-military electronic components would fail miserably. They warned that relying on a vendor to repair and return products just would not work. The users worried about how they would get replacements when the products failed, and how they would continue to operate during that down time. In the final analysis, the established groups were reticent to change the way they had been doing business. They were used to risk avoidance, not risk management! Of course, it would be unfair to represent the CHS experience as all positive. There was a "break-in" or "learning" period where repair and returns were delayed, ordering wasn't as smooth as it could have been, and, in general, the full promise of CHS was not realized. But since that time, the CHS concept has been refined and has matured to an extremely effective mechanism for injecting the latest COTS technology into Army systems.

Case Study #2, Software Development. There is probably no more dynamic technology area than software applications. This area moves faster than any other and consumes more of our development and sustainment funding. While we could discuss specific applications, a more relevant area is the tools used to develop those applications (and the standards associated with them).

CECOM is responsible for bringing to the Army an ever-improving capability to visualize the battlespace and its contents. In the mid-1990's CECOM was asked to investigate the feasibility and utility of 3-Dimensional visualization. At the time, there were few, if any, commercial 3-D toolkits for software developers. Also at that time, computing power was significantly less than today and only the top-of-the-line machines (like those made by Silicon Graphics Inc. (SGI) for the Hollywood movie industry) were even close to being capable to execute real-time, 3-D visualization.



Our initial efforts used a 3-D software product (the Virtual Geographic Information System, or VGIS) developed jointly by one of our sister organizations, the Army Research Laboratory , and Georgia Institute of Technology. We adapted VGIS to meet Command & Control visualization requirements and then focused on the development of prototype applications to satisfy the user's needs. Consolidated into our Battle Planning and Visualization (BPV) system, the applications included route planning (using elevation data for slope analysis and inflection), a cross sectional 3-D view of routes, a 3-D common tactical picture, and more. At that time, the only platform capable of running these applications was the SGI series of workstations.

As time progressed, SGI released OpenGL, an industry standard, platform-independent graphics Application Programming Interface (API). VGIS, developed much earlier, used an SGI platform-specific API called IrisGL. The introduction of this new API created a conundrum. Should we continue to use IrisGL, or port all of our work to the industry standard? Since our target hardware platforms had also changed to Sun Microsystems platforms, we chose to port our applications (and VGIS) to OpenGL.

Within two years, SGI began researching graphics APIs that provided some of the advanced features we had developed in VGIS. But these features were immature, and we could not rely on them (yet). We continued to test the new SGI APIs (as they matured) while moving forward with BPV, and provided continual feedback to SGI as we did. A year later, SGI initiated a collaborative effort with Microsoft Corp. to develop a new cross-platform graphics set of API's called "Fahrenheit". Again, we participated in early trials of the new API while continuing with BPV. While SGI has scaled back its efforts on Fahrenheit, we are continuing our relationship with Microsoft by way of the Fahrenheit Beta program. We expect the final product to form the core of our future 3-D applications.

Our history and approach with the 3-D BPV system epitomizes the speed and danger associated with developing software applications. If we had waited for an industry standard toolset (instead of beginning our development with a "homebrew" toolset), we would have not been able to respond to our customers. On the other hand, if we had then closed our development environment to new tools (and not participated in Alpha and Beta testing with SGI and Microsoft), we would have encountered a "dead end". Our BPV system would have been inexorably linked to the SGI hardware platform, while our customers were using SUN and even PC platforms. BPV would not have been able to take advantage of graphic engine improvements.

Our approach was a "middle of the road" strategy. We kept an open path towards the future, but did not adopt immature products (which, in the case of SGI never matured into an actual product). As a result, our BPV is serving as the basis for new systems for our customers on various hardware platforms. And as COTS technologies become mature enough, we are continuing to integrate them.

Case Study #3, Batteries: Our first two case studies focused on software. But while software has become a major part of today's technology focus, that software needs hardware on which to execute. And that hardware needs power in order to operate. In a tactical environment, you don't have the luxury of commercial power (or even locally generated power for that matter). Thus, portable power in the form of batteries is critical to our customers.

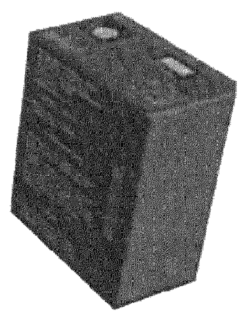
But high-energy batteries required by our soldiers' electronics gear are expensive. So much so, that in the 1990's the Chief of Staff of the Army became concerned at the high cost of batteries that the Army used on a routine basis to keep its soldiers trained and ready. He challenged AMC (and, in turn, CECOM) to reduce that cost by 50%. After some analysis, we found that the major contributor to the cost was a single Army-specific battery, the BA-5590. This battery powered the SINCGARS radio (when it was not being powered by vehicle power systems). With over 200,000 SINCGARS radios used by the Army, arriving at a solution for just the BA-5590 had the potential to meet the Chief of Staff's mandate.

The BA-5590 was a lithium sulfur-dioxide primary (non-rechargeable) battery with high current and energy content in a relatively small (size and weight) package. Any alternative would need to maintain the same form factor and weight, and provide the same capacity so soldiers could still perform their stated missions. CECOM also faced an additional problem. Although the cells used in the batteries are essentially commercial, the battery itself is unique to the military. A commercial battery manufacturer makes more consumer "D" cells in a few days than the total yearly requirement for BA-5590's. Thus, commercial manufacturers are not interested in this "low-volume" market. Instead, the Army relies on less than five specialty houses around the world to assemble its military-unique batteries.

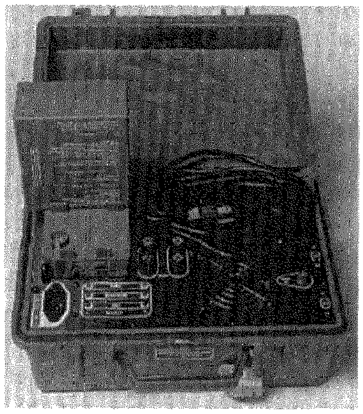
While the Army did improve the BA-5590 primary battery (using newer lithium chemistry), a more interesting aspect of addressing the challenge is what we did to change the "customer's" consuming habits. Over the years the Army had used both non-rechargeable and rechargeable batteries, but it rarely uses the latter for combat. And since the Army chose to train as they fight, rechargeables were not considered appropriate for training either. Years ago, this made some sense. Rechargeable batteries were not very good; they held relatively little energy, took a long time to charge, and could not reveal how much charge was left to the user.

Since that time, however, newer chemistries (nickel metal hydride and lithium ion) have become available. Nickel metal hydride technology was developed by commercial industry to replace nickel cadmium rechargeable batteries, thus addressing the new U.S. Environmental Protection Agency's regulations governing the disposal of products containing heavy metals (in this case, cadmium). Batteries with nickel metal hydride technology provide 50 percent more energy per weight (39 watt-hours per kg) than the old nickel cadmium and lead acid systems. They also suffer no "memory" problems and can be recharged at least 225 times under field conditions. Lithium ion technology was also developed by commercial industry. Their intended application was laptop computers and cell phones that demanded the most energy and power in the smallest and lightest configuration possible. Batteries made with this technology provide 100 percent more energy per weight (52 watt-hours per kg) than the old nickel cadmium and lead acid systems, suffers no "memory" problems and can also be recharged well over 225 times under field conditions

To satisfy the challenge, CECOM had to accomplish three tasks. We had to adopt commercial cells with this newer technology into our military batteries. We also had to adapt commercial charging technology to provide a field recharging system that could recharge a battery in a relatively short time (about 3 hours, versus the 12 hour charge time of the older, military developed charging systems that existed then in the Army inventory). Finally, to gain customer confidence, we had to imbed some sort of "state-of-charge" system into the new batteries so the soldier could get a relative reading of how much "life" was left in the battery. (Put yourself in the soldier's place. If you were going to literally bet your life on a battery, would you guess how much charge was left, or just throw out the one you had before you left on your mission and take a new one? If you did, you'd be throwing away a lot of unused, expensive capacity).



CECOM began by building prototype batteries with commercial (lithium ion and nickel metal hydride) cells, but in the existing military configurations.



In parallel, we contracted for the development and production of a new field charger that used commercial PIC microprocessor technology. (The PIC microprocessor is readily available, inexpensive, and has its instructions stored in erasable programmable read-only memory. This approach allowed us to change the charger's characteristics several times as we built a few chargers, took them to the field, got feedback, and made changes). Finally, we incorporated a 4-Light Emitting Diode (LED) state of charge indicator. The LEDs indicate 25%, 50%, 75%, & 100% of capacity, are inexpensive, and give just the right level of indication to the soldier.

As our experience grew, we produced more batteries and *gave* them to a series of fielded units (along with the new "rapid" chargers). Skeptical at first, the units eventually gained confidence in the new rechargeable system. They also realized that they were saving significant money by not having to buy primary batteries. After two-years of this type of trial, everyone was convinced enough for the Army to formally adopt the rechargeable system for training. In the end, CECOM and AMC more than met the Chief of Staff's challenge.

CECOM was able to adapt commercial lithium ion cell technology to its military unique batteries (similar to our adaptation of commercial microcircuits to our military computing needs). In the process, an interesting synergy evolved between CECOM and industry. While the cell technology provided greatly improved capability, it did it at temperatures only down to 0°F. Since the Army needed to operate much below that temperature, CECOM had been working on an innovative lower temperature electrolyte technology. That technology, developed by CECOM, was shared with industry that, in turn, were able to offer us further improvements in low temperature operation to -40°F.

CECOM was also able to adapt commercial charging and microcircuit technology to both the tasks of charging and determining the state of charge of military unique batteries.

But most important, CECOM was able to change consuming habits and old (albeit somewhat deserved) prejudices against rechargeable batteries. We were able to do this through a partnership with industry that provided us with not only chemistry improvements, but with the capability to work with us to develop, produce, deploy, and modify in a responsive, time-sensitive fashion.

Case Study #4, Land Warrior: In the early 1990's CECOM demonstrated a concept for bringing information technology to the soldier. This initial concept eventually became known as Land Warrior (LW). The envisioned Land Warrior system's capabilities would allow the dismounted infantryman to move and communicate rapidly on the battlefield. He would know at all times his own location, those of his squad members and of the enemy, regardless of terrain or weather conditions; as well as what his squad or team leader expects him to do. Land Warrior would represent advancement in effectiveness over the way today's infantry rifle squads perform collective tasks, since today they still rely heavily on verbal communications (shouting at each other) and hand and arm signals to perform collective tasks.

To achieve this capability, a contract was awarded in the 1990's to Hughes Aircraft Corp. (later acquired by Raytheon Company) to mature the concept into a fieldable system. Based on various requirements from the user (and the fact that the commercial sector was in its infancy in the wearable computer market, and laptop/notebook PCs were about the size of briefcases), Hughes set out to apply a commercially available microprocessor chip, but develop a unique, real-time operating system. After several years and over US $100 Million, the program had not progressed to the fieldable system stage and the US Congress was considering terminating Land Warrior.

In late-1998, a new PM was assigned (COL Bruce Jette, PM Soldier). Although the PM was associated with another MSC, he came to CECOM (where he had previously served) and asked us to perform a third party assessment of the LW program. Our assessment showed a high risk with the existing approach. The PM then contracted with a Silicon Valley firm to perform another independent assessment (this time with a purely commercial eye and focusing on the technology being employed). That firm came to the same conclusion as CECOM. In 1999, the PM asked that Silicon Valley firm to quickly put together a demonstration of what might be possible with today's technology. He also asked CECOM to put together a support cell to bring our technology expertise and COTS-based thinking to LW.

The resultant system is a combination of the adopt, adapt, and develop aspects. Before we identify which is which, let's take a look at the new system itself.

At the core of the integrated Land Warrior system is a small, wearable, computer-radio subsystem, mounted on the soldier's lower back. The current version of Land Warrior uses a small, portable commercial-based IBM-compatible computer, and a Windows-based operating system. This shift to an open commercial architecture will significantly reduce the cost and effort to continually develop and sustain the software. It will also make future product upgrades easier. Finally, it will help us to fine tune and tailor the system, both as technology advances, and as users adapt to the system, identify new needs and propose new capabilities.

The computer displays imagery that the soldier views through a helmet-mounted, monocular viewfinder covering one eye. The Land Warrior soldier sees a miniature computer screen – a "heads-up display", that shows digital maps, graphics, and text in a Microsoft Windows, pull-down-menu format, as well as imagery from the Thermal Weapon Sight or daylight video sight. The view he gets is from the direction at which he points his weapon. The display allows the soldier to find a target and shoot his weapon accurately from a concealed position using either the thermal or the video sight, exposing only his hands. He can even fire his weapon from behind the corner of a building without exposing his head.

The "mouse" control for the computer's menu-driven displays is a small button on the side of the weapon that the soldier manipulates using the fingers on his trigger hand. Each soldier, using a helmet-mounted microphone that sits in front of his mouth, can talk with others in his squad via secure voice radio, akin to an intercom system on an aircraft. Using the pull-down menus, he can digitally transmit spot reports of enemy activity or capture and send a video or thermal image of a target, either to squad members or to higher echelons, all using his mouse control. The soldier can even digitally transmit an automatically formatted "call for fire" (for example, to the artillery), and relay the target's coordinates at the touch of his fingers. In contrast, today's infantrymen must use paper maps and verbally convey spot reports, which are ultimately relayed by radio up the chain of command by the squad leader, and through echelons, before a digital linkage can be established.

The Land Warrior squad leader and his two fire team leaders can communicate with squad members from covered positions using voice radio, or silently using text messages. They are also equipped with a hand-held, flat-panel display that can be used to send orders silently. For example, the squad and team leaders can "write" on the hand-held map display to overlay graphics or short text, such as circling the target objective and marking the route to it. These graphics can then be transmitted to squad members' heads-up displays.

A built-in Global Positioning System receiver provides the soldier's position location to the computer, which also receives location reports from other soldiers in the squad, and are shown as icons on a digital map display. The Land Warrior can use the laser range finder to pinpoint a new enemy position, which then appears as an icon on all of the squad's map displays.

The computer is connected to the Thermal Weapon Sight, which is atop his standard rifle. The computer is also linked to a combined laser range finder and digital compass, with a video TV camera sight (also mounted on the rifle).

To see if we were on the right track with the users, 13 systems were built and delivered to soldiers for their evaluation. Although the initial systems did not meet all of the user's requirements, they did meet many of them. Today, an iterative process is in place to continually evolve and build successive and successfully functioning Land Warrior systems, with a Windows-based, IBM PC-compatible COTS-adapted computer, with commercial interface standards, packaged within a rugged case. In fact, 55 experimental systems will be demonstrated during a Joint Contingency Force exercise, in September 2000. This approach of getting products into the hands of soldiers quickly so they can provide feedback in real time to tell us what's right with the system and what needs to be better, is key to applying information age technology.

So now, let's take a look to see what was adopted, adapted, and developed. In the adopt arena, the computer was replaced with COTS computer components (albeit reconfigured in a customized case). In the process, the system gained processing speed, storage (from 500 MB to over 1.5 GB), and the ability to interface with today's peripherals over IEEE standard interfaces. The software is now being developed with commercial software development tools and has the look and feel of a "windows" environment that many young soldiers are intimately familiar with these days. That software will execute in a COTS windows-based environment.

In the adapt arena, the GPS location device is a COTS-adapted product that will include the greater precision of military GPS with protection from hostile intent. Also being adapted is a COTS heads-up display that replaces the older plasma technology but will be environmentally hardened to withstand the rigors of the foot soldier (including the ability to survive when the soldier parachutes into the area of engagement). Further adaptation is occurring in the Local Area Network (LAN) arena. Soldiers in a squad are connected via a COTS-based wireless LAN that will have higher levels of security than commercially available.

In the develop arena, the soldier's weapon is a standard Army issue product that will eventually be replaced by a new generation weapon currently under development. Then there's the laser rangefinder (developed by Raytheon) and a standard Army-developed and Army inventory thermal weapon sight.

This combined strategy resulted from the needs to inject the latest technology into the system, be interoperable with the ABCS system, and accept the realities of what can be accomplished *now*. A not-insignificant aspect of how this was accomplished in such a relatively short time (when lengthy, previous attempts were not successful) deals with working with the user. Although operationally desirable, many of the requirements cited by the user were driving costly, non-COTS solutions. By working with the user to perform a no-nonsense needs/benefits tradeoff, the PM and CECOM were able to redefine the system. For instance, the user had identified that the time between a soldier being identified and being informed of that fact was originally less than 0.2 seconds. That single requirement drove Hughes to opt for a real time operating system, since the notification had to be routed through the computer. After pragmatic consideration that the soldier's physical response time was significantly greater than 0.2 seconds, the user agreed to a longer response time. This allowed the PM to adopt a commercial computer with a commercial operating system.

Clearly, Land Warrior represents a microcosm of thoughtful application of the adopt, adapt, develop strategy. But the key lesson learned is that human communication, and not technology, is the critical factor in how (or even if) a program is able to reap the advantages of COTS.

Lessons Learned: While the scope of intensity will vary with the technologies being addressed, the pursuit of COTS is clearly preeminent in CECOM's lexicon. But blind adoption of COTS is neither technically desirable nor fiscally sound. Rather, we pursue balance between adopting, adapting, and developing when the other two options do not meet our needs.

Adopting is not free. Funding must be reserved for testing the to-be adopted COTS. It must be capable of fitting within the current system constraints (and every existing system will have constraints). With these conditions met, adopting is the quickest and least expensive approach. A non-fiscal benefit is increased customer satisfaction, since customers will continually compare your solutions to what they can acquire on the open market.

Adapting in a military environment is pragmatically the most common solution. Adapting will usually include some associated level of adoption at either the component or sub-system level. Adapting is an optimum mix of leveraging commercial investment and the customer-environment understanding of your organic workforce. While adapting may not seem as quick or inexpensive as adopting, when the user environment is factored in, it is.

Developing must be reserved for those unique circumstances where no commercial solution can form either the total answer or a foundation for the answer. Development can no longer be considered a stand-alone effort; in today's fiscal environment, this is a sure recipe for disaster. Rather, development must be pursued as a partnership where industry is "seeded" with an initial investment (of money or technical knowledge). Properly nurtured, that seed will grow into a solution that services your customers and provides a cost-effective manufacturing base.

Only One Piece Of The Puzzle: Technology, that is. Through its significant experience in the pursuit of COTS, CECOM has learned that customer requirements and expectations are as important (or possibly more important) than the pure technology.

As with CHS (Case Study #1) and batteries (Case Study #3), customer pardigms must be understood and thoughtfully modified. Nothing breeds success like success. Early, moderate successes are much more important than the 100% solution that takes too long.

Many military customers identify requirements without the benefits that moderate trade-offs could bring. As with Land Warrior (Case Study #4), a simple trade-off in response time can allow system design that opens up the system architecture, provides a better user interface and, in general, holds the potential for greater, longer term user satisfaction.

The Difference Is Blurring: As we indicated in Case Study #2, the rapid and fluid software environment that many associate exclusively with the commercial sector is just as applicable to the military. In fact, customer expectations demand no less. And this shift extends to the information technology hardware associated both directly with software (like computers and peripherals) and indirectly (like software-programmable radios). The decisions we make in development drive the long term future of the resultant product. Selecting a COTS solution is not a trivial matter and can drive life cycle costs significantly. To make the most informed decisions, we must monitor COTS product forecasts like the stock market, and be ready to shift when necessary, or potentially pay the price for remaining static. A reminder of this was a past decision to equip all of the Navy's recreation centers with higher quality "Betamax" VCRs, instead of VHS, right about the time VHS became the consumer product of choice. Inclusion of commercial products can potentially reduce life cycle costs in military system or platform development, by leveraging in the commercial product's economies of scale, but only if there is an "active" economy of scale to work with.

Conclusion: The reality is that the significant investments being made by the commercial sector in Information Technology are orders of magnitude greater than the US military can afford to drive or influence. CECOM has recognized this and embraced an adopt, adapt, develop philosophy. We leverage commercial investment by anticipating (through technology forecasts) and building meaningful, regular interactions with industry. In these ways, we can better anticipate the direction the market is going so we can match technology trends to soldier's needs.

But as the four case studies presented infer, any decision "today" to adopt, adapt or develop, may be different "tomorrow". There is no specific formula we can calculate because the variables are continually changing. But some things *are* constant. We ensure continual interaction with the customer. We value continual technical curiosity and acumen. We foster a continuing demand to not stick with yesterday's process. And, above all, we continually keep a balance between being the earliest-adopter and one who stands still. Because in the business of equipping the US soldier with the best technology in the world, the consequences of doing it wrong (or doing it too late) can be, literally, deadly.